PRELIMINARY PLANT VISIT
INDUSTRIAL HYGIENE REPORT

Formaldehyde Production Facility
Monsanto Plastics and Resins Company
855 Seneca Road
Eugene, Oregon

PARTICIPANTS:
John Pate, C.I.H., GEOMET Technologies, Inc.
Glen Barrett, C.I.H., GEOMET Technologies, Inc.
Dave Dunn, Monsanto Research Corporation
William McKinnery, NIOSH

PREPARED FOR:
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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MONSANTO RESEARCH CORPORATION
DAYTON LABORATORY
Dayton, Ohio 45407

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1. INTRODUCTION

This preliminary industrial hygiene survey report describes the Monsanto Company plant located in Eugene, Oregon. This plant was selected for a preliminary industrial hygiene survey because of the moderate production (approximately 100 million pounds/year), the use of silver catalyst, and the Northwestern location.

1.1 PLANT PERSONNEL CONTACTED

The plant visit described in this report was carried out by John Pate and Glen Barrett (GTI), Dave Dunn (MRC), and William McKinnery (NIOSH) on August 20, 1981. Personnel contacted in connection with the visit included Mr. Jim Morris, the Plant production supervisor, and Mr. John Wheeler, the Manufacturing superintendent.

1.2 SUMMARY OF ACTIVITY

The plant visit team met with plant personnel and held an extended conference during which the process, control technologies, and industrial hygiene programs described in this report were discussed. The group then walked through the formaldehyde portion of the plant, following the process flow, and discussed aspects of the process. A closing conference was held during which information from the walk-through was discussed further.

2. BACKGROUND

The National Institute for Occupational Safety and Health (NIOSH) and the U.S. Environmental Protection Agency (EPA) have entered into an interagency agreement to perform a study that will determine the levels of pollutants to which workers in the formaldehyde production industry are exposed and to evaluate the effectiveness of control technologies currently used to minimize exposures. A similar study of the semiconductor industry is being conducted simultaneously. The results of both studies will be reports that will assess the current state-of-the-art in control technology in the industries studied and that will describe exposures of selected workers to pollutants, both on and off the job.

EPA has contracted with Monsanto Research Corporation (MRC) to perform the study on the formaldehyde production industry, under EPA Contract Number 68-03-3025, entitled "Technical and Engineering Services." MRC is being assisted in the study by personnel from GEOMET Technologies, Inc.

The study of the formaldehyde industry is being directed toward a cross section of production facilities. Of principal importance are the assessment of worker exposure to potentially hazardous agents in the workplace and an evaluation of control technologies applied to those agents. The worker exposure (industrial hygiene) study will examine all agents associated with formaldehyde production processes. Process agents of concern and the workforce exposed to such agents will be identified, concentrations evaluated, and the operations and process parameters of the worksite will be characterized.

A limited number of volunteers will be selected from the workers at a few sites for the determination of total (24-hour) exposure to air contaminants, including those found in the workplace,

in-transit, at home, and elsewhere. This portion of the study will be designed in such a way that it can be used to estimate the total average daily exposures of worker populations to air contaminants. These contaminants will be measured by personal and area monitors and will include those contaminants found in the workplace as well as others commonly found in the outside air and residential environments.

The focus of the workplace control technology study will be the assessment of control technology currently in use or available for minimizing worker exposure to harmful chemical or physical agents. The assessment will include examination of processes and process equipment. Control effectiveness will be determined through observation of work practices, examination of the equipment condition, and engineering controls (e.g., ventilation), monitoring devices, personal protective equipment, and air sampling and analysis. The costs of controls versus their effectiveness will also be examined.

The following sections briefly describe the objectives of the two segments of this project. The Industrial Hygiene/Control Technology Assessment segment includes two phases, a preliminary walk-through survey, and a detailed survey.

This report constitutes the conclusions of the preliminary survey of the production plants. The 24-hour exposure profile section is a related segment. This segment will study the workplace, the residence, and the in-transit modes of the formaldehyde production worker.

2.1 OBJECTIVES OF THE INDUSTRIAL HYGIENE/CONTROL TECHNOLOGY ASSESSMENT (IH/CTA) STUDY

The objectives of the IH segment of this study are:

- Identify potential hazards to workers,
- Evaluate these potential hazards for the effects or exposures to workers,
- Evaluate the effectiveness of industrial hygiene control programs for these potential hazards.

The objectives of the CTA study are to:

- Assess current formaldehyde production technology with respect to control of potential exposures of workers,
- Identify the best available means to control emissions and potential exposures,
- Evaluate the state-of-the-art of control technology in the formaldehyde production industry,
- Assist the transfer of control technology inter- and intra-industry,
- Identify processes for which engineering controls are not available or are ineffective, where further research and development are needed, and to indicate priorities for application of control technology.

This study is divided into two phases, preliminary industrial hygiene surveys and detailed industrial hygiene surveys. Objectives of these phases are presented below.

2.1.1 Objectives of the Preliminary Industrial Hygiene Survey (PIHS)

The objectives of these visits are to:

- Identify potential exposures to hazardous agents in formaldehyde processes and operations,
- Identify control technology currently used by the formaldehyde industry to eliminate or modify potential exposures,
- Prepare a series of preliminary plant visit reports detailing findings from the first two objectives,

- Select 4-5 candidate plants from the original 12 plants for later detailed industrial hygiene surveys, based upon the findings from the first two objectives.

2.1.2 Objectives of The Detailed Industrial Hygiene Survey (DIHS)

Detailed plant visits comprise the second phase of the study. The objectives of these visits are to:

- Observe operator work practices,
- Conduct quantitative personal sampling,
- Evaluate engineering control techniques used by the industry to reduce exposures,
- Prepare a series of detailed plant visit reports, detailing worker practices and evaluating the engineering controls used by the plant.

This part of the IH/CTA segment will be coordinated with the 24-hr exposure profile at four selected plants.

2.2 OBJECTIVES OF THE 24-HOUR EXPOSURE PROFILE

The objectives of the 24-hour exposure profile segment are:

- Determine the exposure of selected formaldehyde production and office workers to five selected pollutants on a 24-hour basis,
- Evaluate these results and identify potential areas of concern due to high exposure,
- Determine the need for further indoor air studies.

3. DESCRIPTION OF PLANT

The Eugene, Oregon plant is located in a moderately industrialized area on the outskirts of the city. The plant, which is 17 years old, produces 50 percent formaldehyde solution by using silver as a catalyst. The formaldehyde is used on-site to produce a resin which is then sold to local plywood and particleboard manufactures.

The formaldehyde and resin production units are housed in a single structure, sharing a common combined control room and laboratory. Most of the formaldehyde operations are located in the open air around the structure and thus are well ventilated. Only the formaldehyde converter and resin reactor are located inside the structure. The storage tank for methanol and formaldehyde are located across a site shipping road approximately 75 feet away. An office building is adjacent to the structure. The plant manager's office, as well as additional on-site offices, are provided in a separate building isolated from the area.

The entire plant, including formaldehyde and resin production operations, laboratory research, and a sales group, totals 31 non-union employees. Of this total, four operators, one per crew, work on the formaldehyde unit. These operators alternate between the formaldehyde unit and the resin unit. Each crew works an 8-hour shift. Operators handle all aspects of formaldehyde production including unloading methanol from railroad tank cars, sampling and analysis of the process streams at several points, and operating and monitoring the process from the control room. Maintenance workers at the plant are assigned to the day shift only, but are also on 24-hour call.

4. PROCESS DESCRIPTION

Formaldehyde is manufactured by methanol dehydrogenation. Hydrogen gas and residual methanol produced in the process and oxidized with air provides heat needed for the dehydrogenation reaction. Attachment A is a schematic of the overall process used at the Eugene plant.

Initially, methanol is pumped from a rail car to a bulk storage tank and then to a vaporizer, where it is vaporized. Air, after passing through a primary filter and water wash cleaner, is preheated and combined with vaporized methanol just prior to a converter containing crystalline silver catalyst. The formaldehyde gas from the converter is fed to an absorber where the formaldehyde and unreacted methanol are cooled and absorbed in water. The resulting solution is pumped from the bottom and middle of the absorber through heat exchangers to cool the solution which is partially recycled to the absorber. The liquid effluent from the bottom of the absorber is pumped through another heat exchanger prior to being fed into a distillation column. Off-gas from the absorber cosisting of 80 percent nitrogen and 20 percent hydrogen is used as fuel in an incinerator. Excess methanol is removed and a 50 percent formaldehyde solution (50% formaldehyde, 49 percent water and 1 percent methanol) is produced in the distillation column. This product solution is passed through a product cooler and stored at 55°C in a bulk storage tank. Methanol vapors off the top of the distillation column are condensed and recycled to the methanol bulk storage tank when not recycled to the distillation column for refluxing.

The process has been operating as described since the original plant startup in 1964. The incineration of the absorber off-gas has been in existence for the past three years. Otherwise, no other major changes in the process have been installed.

5. DESCRIPTION OF THE INDUSTRIAL HYGIENE PROGRAM

The current industrial hygiene program at the plant was initiated in 1976. Baseline sampling data for formaldehyde was completed in 1977 by a corporate technician. Monitoring has been performed at least once each year since then. Sample results are reported in Section 6. Colorimetric detector tube samples are also taken for formaldehyde and methanol by the plant supervisor, if it is felt excessive concentrations may be present. If sample results indicate a potential for excessive exposure, personal samples are then taken by the plant supervisor to obtain more accurate results.

The plant has completed compiling an environmental assessment statement as required by their corporate office. This statement includes a summary of workplace sampling data as well as potentially harmful wastestreams.

Training of formalin operators includes 1 to 3 weeks of classroom training by the production supervisor, followed by approximately 3 weeks of experienced operator observation, followed by another month of on-the-job training. Training includes safety and health program training. Employees are trained in such a manner that anyone can shut down the plant if a severely unsafe condition is observed. Job turnover is very low. Out of the total number of employees, there has only been three personnel changes in 17 years , with two employees retiring in 1980. There have been no lost-time injuries or illnesses in the 17-year existence of the plant.

Safety glasses and hard hats are required for anyone working in or observing any of the production facilities. All production workers are furnished safety glasses, safety shoes, and hard hats, as well as work clothes, which are laundered weekly by the plant. Neither lighters nor matches are allowed because of potential fire and

explosion hazards. Chemical goggles, a face shield, and protective gloves are provided for routine operations, such as unloading of methanol or formalin. Cabinets of protective clothes are located throughout the facilities for easy use. Entry into the formalin bulk storage tank for the purpose of cleaning and removal of paraformaldehyde requires that the operator wear a complete protective suit, boots, and a self-contained breathing apparatus. Before entering, the tank is sampled for formaldehyde and oxygen content to determine if explosion hazards are present.

The methanol unloading area is equipped with an emergency eye wash and shower at ground level and on the work platform where the operator works, opening the tank car hatches and inserting and removing the dip pipe. The formalin loading platform, where formalin is loaded into truck tankers is not equipped with an emergency eye wash and shower. However, eye wash and safety shower are located at ground level below the platform. An alarm is sounded whenever the chain for an emergency shower is pulled to immediately alert other employees to provide aid to the employee using the shower.

All employees are required to take a general physical examination every 2 years. The examination does not include a medical evaluation for exposure to a specific air contaminant. The plant does not employ a physician or nurse. An occupational physician, specializing in industrial medicine, is on call for any emergencies. All production employees are trained in first aid through the American Red Cross.

The two maintenance employees assigned to the day shifts are on call in the evening to perform major maintenance if needed. If a minor equipment leak is discovered in the evening by an operator, the leak is recorded in a log book and repaired immediately by a maintenance employee the next morning. If the leak is judged to

present a hazard, maintenance is called in to repair it at once. Pump seals, valve stems, and pipe flanges are checked periodically by maintenance. If a pump motor sounds or acts differently due to poor operation or solution leaks are detected, maintenance inspects the motor and pump and repairs it. Repaired equipment is recorded in a maintenance log. Some formaldehyde was smelled by the survey team outside the structure, near the still, and in the converter room.

6. SAMPLE DATA

Plant baseline sample data for formaldehyde obtained in 1977 by the production supervisor ranged from 0.7 to 1.98 ppm. The impinger personal sampling method was used; sample duration was 20 minutes. 1.98 ppm was obtained for the operator drawing a sample off of an absorber heat exchanger and analyzing the sample in the production lab. It was determined that the major source of formaldehyde was analysis of the sample in the lab. Locally exhausted laboratory hoods were installed in the lab to reduce this problem. These hoods have been demonstrated to correct the problem of formaldehyde exposure.

Personal or detector tube formaldehyde samples are taken yearly or as needed. Long-term (450 minutes) personal samples were taken with Tenex sampling tubes by a corporate employee in 1980. The exposure for 75% of the formalin operators was determined. Sample results ranged from 0.09 to 0.19 ppm, which are much less than the current Federal time-weighted average limit of 3 ppm. An area sample was taken in the production lab (Tenex sample tube, 427 minute sample duration) with results of 0.25 ppm. Two short-term personal samples (38 and 30 minutes duration) were taken by the production supervisor on formalin operators while they were drawing product samples for analysis in the production lab. Results were 0.12 and 0.14 ppm.

OSHA inspected the facility in January 1981. A short-term impinger sample was taken (37 minute sample duration), with a result of 0.21 ppm. The sample was taken on a formalin operator while he withdrew samples from an absorber heat exchanger and the still cooler and analyzed the samples in the production lab. These sampling results indicate a reduction in formaldehyde exposure when compared to the 1977 samples.

Noise-level readings have been taken with a GenRad sound-level meter and a Dupont audio dosimeter. Noise-level readings obtained with the sound-level meter in 1978 were: 76 dBA -- formalin control room, 88 dBA -- converter room, 90 dBA -- source exposure near the outside air blower. Time-weighted average noise level exposures obtained with the audio dosimeter in 1978 for two formalin operators were both less than 80 dBA. 115 dBA was never instantaneously exceeded.

7. CONTROL STRATEGY

Several areas of the formaldehyde operation that present exposure potential are discussed below with respect to the applied control technology and the recognition of exposure. Exposure reduction is achieved by totally enclosing the process. An exception is the initial open entry point of methanol into the process.

Leaks and spills of the process vapors and solutions can occur from mechanical equipment used. Leaks were smelled during the walk-through but no samples were taken during the survey.

7.1 METHANOL UNLOADING AND HANDLING

Methanol is unloaded from tank cars through a quick-connect dip tube and a swivel draw pipe (Figure 1). This approach requires the operator to spend only a few minutes on the tank car and reduces the amount of operator exposure during the preparation for transferring the methanol to the methanol storage tank. As the methanol is pumped out of the car, air is drawn in through the opened top due to volume displacement. This prevents methanol vapors from escaping from the top of the tank car. The methanol is stored in a large tank that releases methanol vapors to the atmosphere during filling. The tank is approximately 30-40 ft tall and is exposed to natural constant wind of 3 mph.

A centrifugal pump with a packed seal is used to pump the methanol out from the methanol tank. The level inside the tank is measured by a remote level indicator, with no worker exposure, except in rare cases. No leaks were evident and no methanol was smelled.

7.2 REACTOR ROOM AND CONTROL ROOM

The reactor room is enclosed in the main structure (Figure 2). The exposure of the worker to both chemicals of concern, methanol and formaldehyde is possible in this area.

Figure 1. Methanol unloading area.

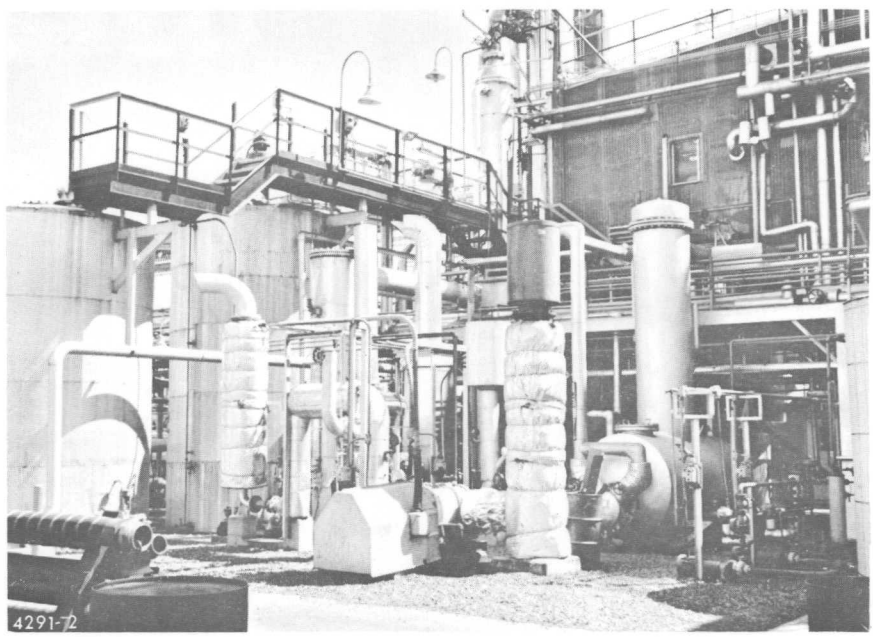


Figure 2. Enclosed reactor room in upper left hand corner. Methanol vaporizer in lower section.

Several potential leak points are present around the reactor and process gaskets presenting a potential for the methanol and formaldehyde vapors to enter the reaction room. The leak points at the gaskets may be enhanced because of the high temperature service required for the reactor. Formaldehyde was sensed (smelled, slightly burning eyes) in the reactor room but no source was definitely located. Methanol was not found on a subjective basis. Ventilation in the reactor room is provided by two roof vents in the ceiling.

The control room/laboratory is located directly adjacent to the reactor room. Here, the operator tests the solutions for formaldehyde concentration and monitors the process. The area is equipped with chemical hoods, which vent to the outside, as well as a 12-15 inch diameter fan in a side wall. All sample preparation and analysis work is done inside the hoods except for determining the refractive index.

7.3 ABSORBER AND DISTILLATION COLUMN

From the reactor the hot formaldehyde and methanol gases enter an absorber located outside. The absorber is equipped with recycle pumps that transfer the absorber solution from collection trays in the absorber to the top of the absorber sections after passing through heat exchangers. Formaldehyde was detected by eye and nose irritation in this pumping area. Inspection of the pumps, indicated small paraformaldehyde formations which may have been the cause of the formaldehyde detection (Figures 3 and 4). These pumps are centrifugal pumps with mechanical seals combined with water washed thermatalic seals. The water wash from these seals dilutes the formaldehyde solution, if it leaks, and carries it into the sump under the plant prior to wastewater treatment. All formaldehyde solution pumps are equipped with these seals.

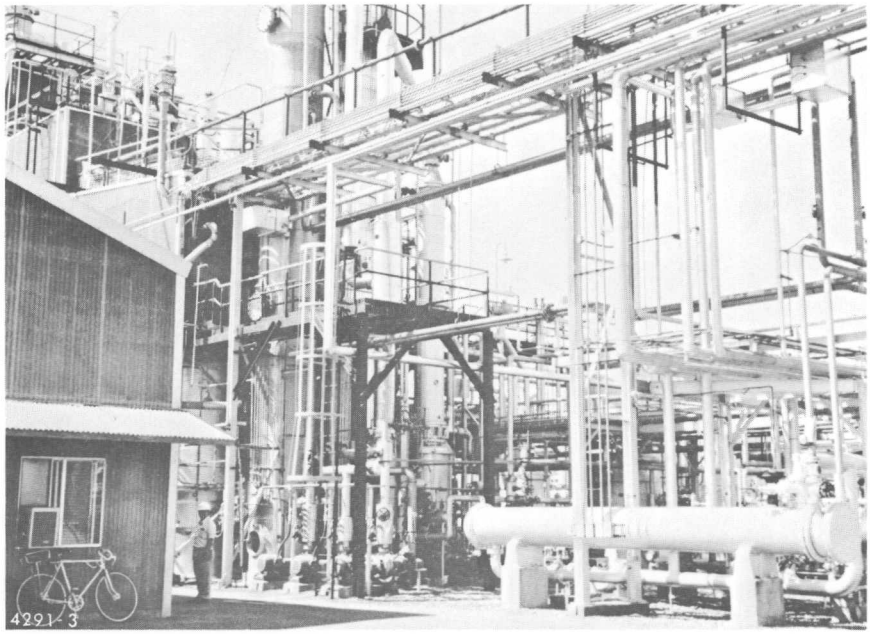


Figure 3. Absorber pump area.

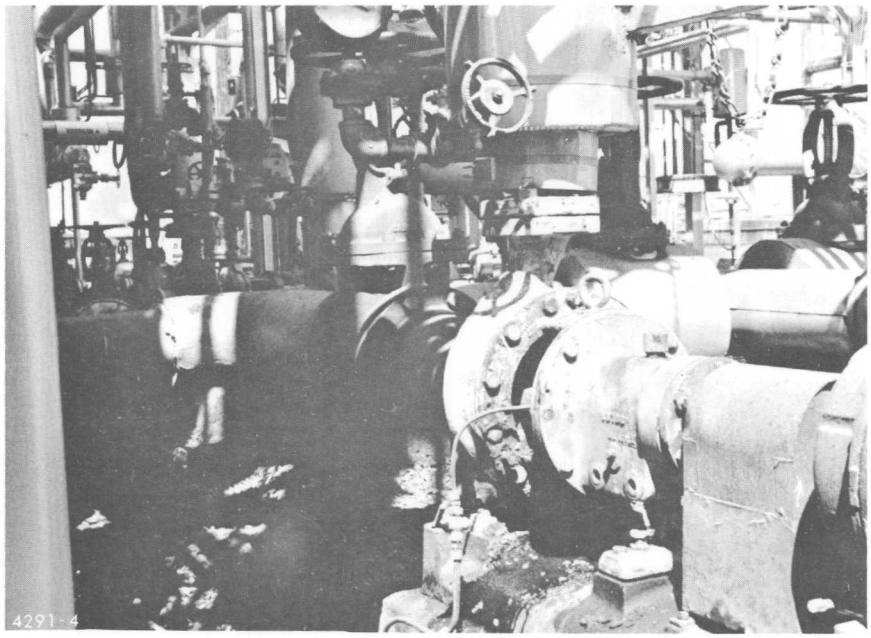


Figure 4. Closeup of absorber pump. Note water wash drainage on base.

The distillation column is located adjacent to the absorber. The pumps used to transfer the formaldehyde from this column to the distillation column heat exchanger and the product cooler also had small paraformaldehyde formations (see Figure 5). In addition, a large formation of paraformaldehyde, was found a line drain valve located on the outlet of the distillation column going to the product cooler (see Figure 6).

7.4 FORMALDEHYDE STORAGE

Cooled formaldehyde from the distillation column is stored in a large tank in a diked area directly adjacent to the methanol tank. The formaldehyde is stored at approximately 50°C to prevent paraformaldehyde buildup and is recirculated using a water sealed pump discussed earlier. A second similar pump transferred the formaldehyde for resin production (Figure 7). No formaldehyde was smelled in this area.

In general, all pipes and storage tanks are labeled. Pipes are not color-coded according to the chemical transported in the pipe. All tanks are equipped with automatic leveling gauges. Thus, operators will not be additionally exposed to formaldehyde and methanol through manual-level gauging.

7.5 SAMPLING POINTS

To ensure product quality, samples are taken from several sampling points including the absorber and distillation product lines. Two of the sample points are shown in Figure 8. Sample points are equipped with a small ball valve to release a purge stream and the sample. Small paraformaldehyde formations were present at these points but may be due to the sampling procedure rather than leaks. Formaldehyde was sensed in this area.

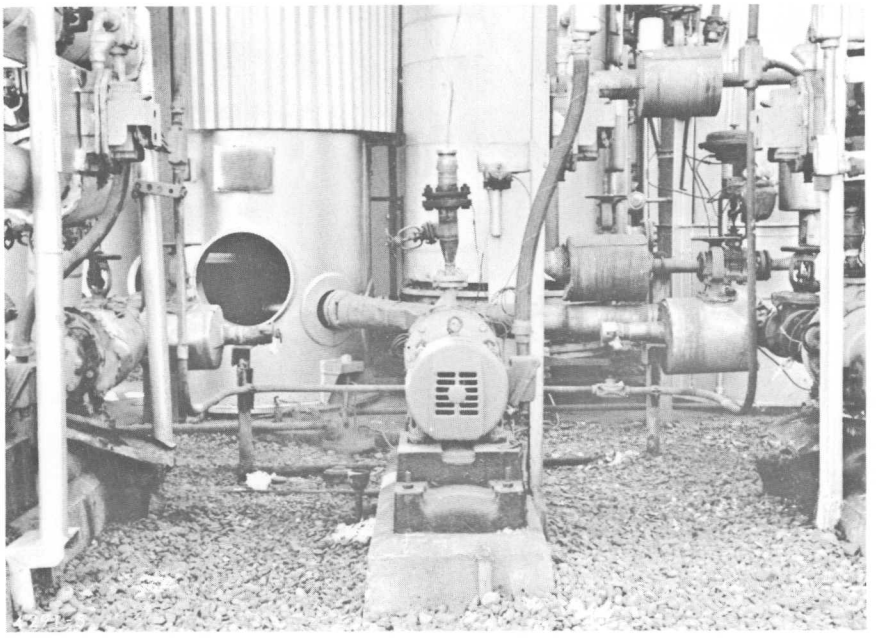


Figure 5. Spare pump from absorber.

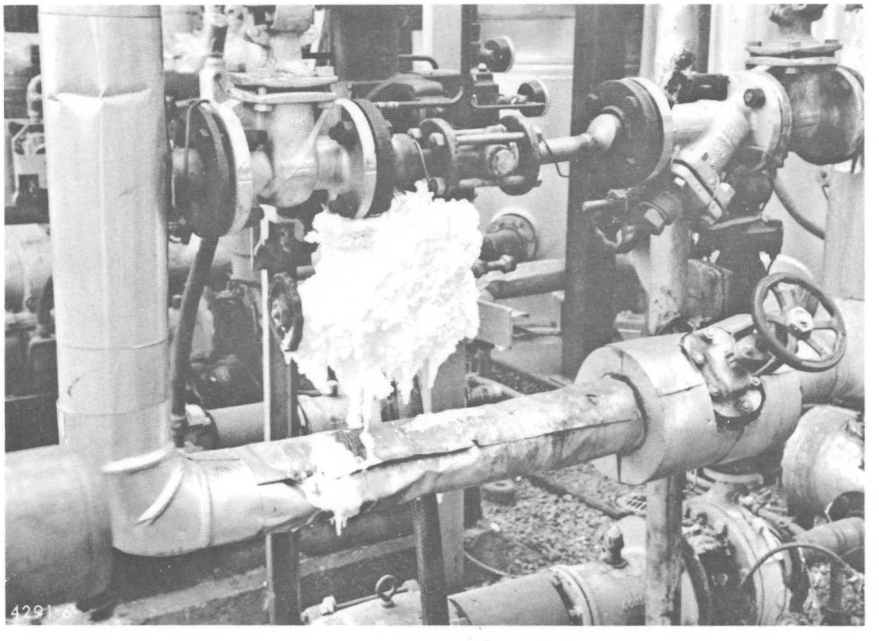


Figure 6. Paraformaldehyde formation on distillation column outlet.

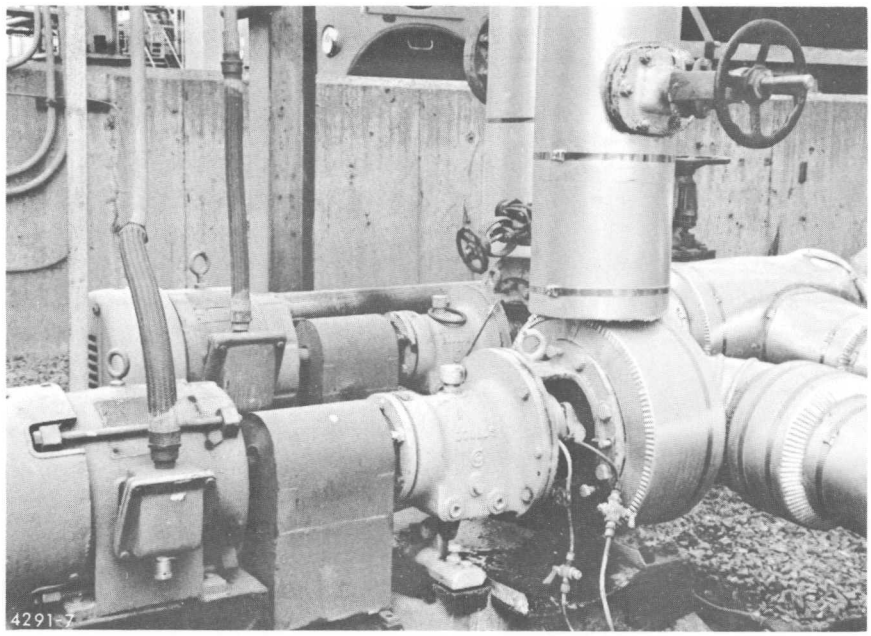


Figure 7. Formaldehyde recirculation pumps. Note water wash.

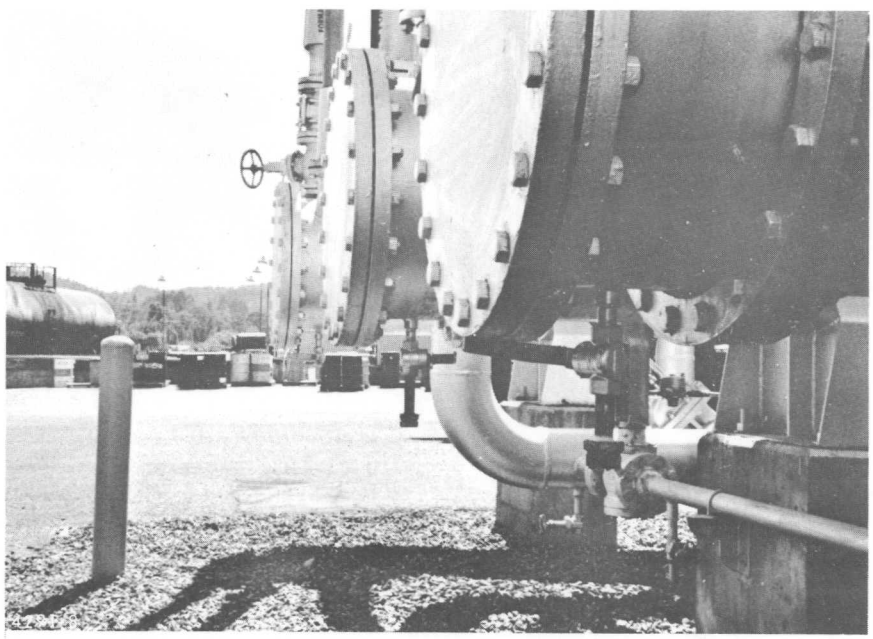


Figure 8. Sampling ports on heat exchangers. Note small paraformaldehyde formation on closest port.

7.6 MONITORING

No continuous monitoring equipment is in use. Impingers and Tenex tubes have been used to periodically monitor the formaldehyde gas exposure.

7.7 PERSONAL PROTECTIVE EQUIPMENT

The operator unloading methanol is specifically required to wear chemical goggles and protective gloves. The operator loading formalin into tanker trucks is required to wear chemical goggles plus a face shield and protective gloves. When an operator withdraws and analyzes a sample, he is required to wear safety glasses and protective gloves.

Self-contained breathing apparati are located in the production lab, at the weigh shed, and in the office conference room, which is designated as the emergency control area. The self-contained breathing apparatus and air-supplied respirators are checked monthly. An air-purifying respirator, which is NIOSH-approved for nontoxic dust, is also provided when needed. Respirator fit testing is not performed. The plant does have a written emergency procedure plan.

7.8 WORK PRACTICE

Since operators do not remain at potential methanol or formaldehyde sources for a long period of time, the potential for excessive exposure is reduced. The results of past sampling programs indicate levels of exposure below 0.5 ppm.

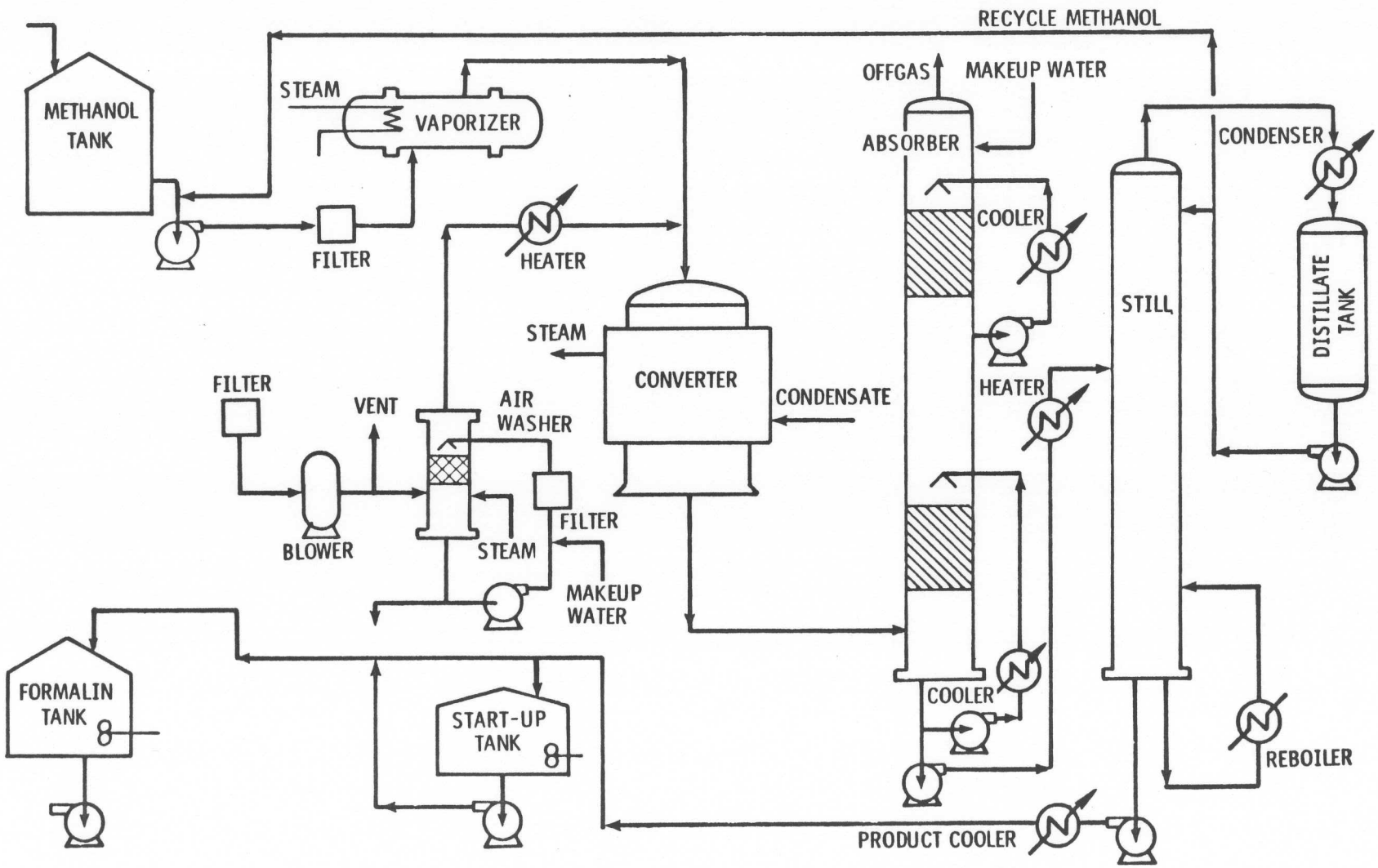
8. CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

The plant demonstrates an effective engineering control program. Although leaks were detected, the maintenance program appears to be operating in an effective manner. All leaks, except for the product cooler line from the distillation column, are minor and are probably due to the type of seals (water rinsed) on the pumps. Emergency protection, personal protective equipment, work practices, the training program, maintenance, and the sample monitoring program all indicate a good awareness of potential exposure points and necessary controls are in place.

8.2 PROBLEM AREAS

Specific problems noted at this plant were: the lack of an emergency eye wash and shower on the formalin loading work platform, and evidence of a formaldehyde pipe leak, through the appearance of paraformaldehyde, which had not been repaired.



Attachment A: Formaldehyde Process Flow Diagram.